**Variations in Neonatal Length of Stay of Extremely Preterm Babies: An International Comparison Between iNeo Networks**

Sarah E. Seaton PhD1, Elizabeth S. Draper PhD1, Mark Adams PhD2, Satoshi Kusuda PhD3, Stellan Håkansson MD, PhD4, Kjell Helenius MD, PhD5, Brian Reichman MBChB6, Liisa Lehtonen MD, PhD5,Dirk Bassler MD, MSc2, Shoo K. Lee MBBS, PhD7, Maximo Vento MD, PhD8, Brian A. Darlow MD9, Franca Rusconi PhD10, Marc Beltempo MD, MSc11, Tetsuya Isayama MD, PhD12, Kei Lui MD13, Mikael Norman MD, PhD14, 15, Junmin Yang MSc7, Prakesh S. Shah MD, MSc7, Neena Modi MD FMedSci16 for the UK Neonatal Collaborative; on behalf of the International Network for Evaluating Outcomes of Neonates (iNeo) Investigators\*

\*A list of participating iNeo investigators and their affiliations, including the UK Neonatal Collaborative Leads is presented in Appendix A.

**Affiliations**

1 Department of Health Sciences, University of Leicester, Leicester, UK

2 Department of Neonatology, University Hospital Zurich, University of Zurich, Zurich, Switzerland

3 Neonatal Research Network Japan, Maternal and Perinatal Center, Tokyo Women's Medical University, Tokyo, Japan

4 Department of Clinical Sciences/Pediatrics, Umeå University Hospital, Umeå, Sweden

5 Department of Paediatrics and Adolescent Medicine, Turku University Hospital and University of Turku, Turku, Finland

6 Gertner Institute for Epidemiology and Health Policy Research, Sheba Medical Centre, Ramat Gan, Israel

7 Department of Pediatrics, Mount Sinai Hospital and University of Toronto, Toronto, Ontario, Canada

8 Division of Neonatology and Health Research Institute La Fe, Valencia, Spain

9 Department of Paediatrics, University of Otago, Christchurch, New Zealand

10 Unit of Epidemiology, Anna Meyer Children’s Hospital, Florence, Italy

11 McGill University, Montreal, Quebec, Canada

12 Division of Neonatology, Center of Maternal-Fetal Neonatal and Reproductive Medicine, National Center for Child Health and Development, Tokyo, Japan

13 School of Women’s and Children’s Health, University of New South Wales, Australia

14 Department of Clinical Science, Intervention and Technology, Karolinska Institutet, Karolinska University Hospital, Stockholm, Sweden

15 Department of Neonatal Medicine, Karolinska University Hospital, Stockholm, Sweden

16 UK Neonatal Collaborative, Neonatal Data Analysis Unit, Section of Neonatal Medicine, School of Public Health, Faculty of Medicine, Imperial College London, London, UK

**Corresponding Author:** Sarah E Seaton, Department of Health Sciences, University of Leicester, University Road, Leicester LE1 7RH. Email: [sarah.seaton@leicester.ac.uk](mailto:sarah.seaton@leicester.ac.uk). Tel: 0116 2525434.

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**Author Contributions**

SES, ESD and NM developed the idea for the study. SES designed the analysis plan and JY undertook all statistical analyses. MA, SK, SH, KH, BR, LL, DB, SL, MV, BD, FR, MB, TI, KL, MN, PS, NM provided clinical input and interpretation. All authors have approved of the final version of the manuscript as submitted and all agree to be accountable for all aspects of the work in ensuring that questions related to its accuracy or integrity are appropriately investigated and resolved.

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**ABSTRACT**

**Objective**

To compare length of stay (LOS) in neonatal care for extremely preterm babies admitted to networks participating in the International Network for Evaluating Outcomes of Neonates (iNeo).

**Study design**

Data were extracted for babies admitted from 2014 to 2016 and born at 24 to 28 weeks’ gestational age. Median LOS was calculated for each network for babies who survived and those who died while in neonatal care. A linear regression model was used to investigate differences in LOS between networks after adjusting for gestational age, birthweight z-score, sex, and multiplicity. A sensitivity analysis was conducted for babies who were discharged home directly.

**Results**

A total of 28,204 babies were included. Observed median LOS for babies who survived was longest in Japan (107 days); this result persisted after adjustment (20.7 days more than reference, 95% CI: 19.3 to 22.1). Finland had the shortest adjusted LOS (-4.8 days less than reference, 95% CI: -7.3 to -2.3). For each week’s increase in gestational age at birth, LOS decreased by 12.1 days (95% CI: -12.3 to -11.9). Multiplicity and male sex predicted mean increases in LOS of 2.6 (95% CI: 2.0 to 3.2) and 2.1 (95% CI: 1.6 to 2.6) days, respectively.

**Conclusions**

We identified between-network differences in LOS of up to three weeks for extremely preterm babies. Some of these may be partly explained by differences in mortality, but unexplained variations may also be related to differences in clinical care practices and healthcare systems between countries.

**INTRODUCTION**

Estimating length of stay (LOS) in neonatal care has historically received little attention. However, in recent years, as survival of extremely preterm babies has increased (1-3), researchers and clinicians have begun to focus on LOS (4,5). As the survival of extremely preterm babies increases, more now have long stays in specialist neonatal units. This leads to a need for increased capacity to care for these babies before they are well enough to be discharged home. National or international guidance around the optimal or appropriate LOS in this high-risk population is limited. Furthermore, there is a need to balance the aims of shortening LOS as much as possible, to reduce healthcare costs and minimise separation of families (6), with the need to ensure safe care management at home or in the community.

Much of the previous research on neonatal LOS has focussed on babies who survive to discharge from neonatal care (7), as including or considering those who die can complicate analysis. However, in this high-risk group of extremely preterm babies, mortality is important to consider alongside LOS, especially for babies born at extremely low gestational ages. International differences in LOS may reflect differences in the survival of very low gestation babies due to the varying organization structures and policies of different healthcare systems.

To-date there have been only 2 small studies comparing LOS across different European regions: the Effective Perinatal Intensive Care In Europe study (EPICE) (8), and the European Health Care Outcomes, Performance and Efficiency study (EuroHOPE) (9). The EPICE cohort (8) considered babies born at 22 to 31 weeks’ gestational age, which is a diverse cohort, particularly due to variations between countries in resuscitation practices and reporting of live births (10) at the extremes of viability. The most recent data used in EPICE were from 2012 and LOS may also have changed since that time. Similarly, the EuroHOPE study (9) used data from 2006 to 2008 and investigated a combination of babies born very preterm and those with very low birthweight.

Exploring and understanding international differences in LOS is important in a society where all healthcare services aspire to provide the highest quality of patient care at the lowest possible cost. The International Network for Evaluating Outcomes of Neonates (iNeo) was established in 2013 to support research collaboration between regions and countries (11,12). In our study, we compared neonatal LOS across a range of networks, continents and healthcare settings for the first time. We chose to focus specifically on the most vulnerable population of babies born extremely preterm (24 to 28 weeks gestational age) and to consider the effects of survival status.

**METHODS**

**Study population and inclusion criteria**

We included all babies born at 24 to 28 weeks’ gestational age between January 1, 2014 and December 31, 2016 and admitted for neonatal care on the first day following delivery to hospitals participating in the iNeo collaboration. Gestational age was determined using the following hierarchy: best estimate based on early prenatal ultrasound, last menstrual period, or physical examination at birth. The iNeo collaboration comprises data from regional networks on admissions to neonatal units from 11 high-resource countries, representing 10 networks, across 4 continents: Australia & New Zealand, Canada, Finland, Israel, Japan, Spain, Sweden, Switzerland, UK (England), and Italy (Tuscany). We excluded babies who were discharged to a non-neonatal facility (i.e. pediatric ward, PICU, out of the country, rehabilitation or palliative care) before home, those who were discharged before 34 weeks post-menstrual age (as these were likely to represent data errors as babies are rarely discharged this early), and those who stayed in neonatal units for longer than 6 months.

**Primary outcome**

The primary outcome of interest was LOS, calculated as the difference between the date of first admission and date of last discharge from the neonatal unit within the data collection system.

Since the organization of care practices, regionalization of care, and system capabilities differ between countries participating in iNeo, we obtained information on discharge destination for each baby. In certain countries, data from step-down neonatal units where babies were transferred prior to discharge home were not available. Information about the data collected for each country is presented in **Table 1**.

**Data sources**

The regions or countries participating in iNeo routinely collect data of which a subset of variables are provided to iNeo, creating a minimum dataset of defined variables that are harmonized as far as possible to ensure consistency across countries (12). Characteristics of the countries or networks participating in iNeo can be found elsewhere, along with details of the data collection and harmonization processes (12,13).

**Statistical analysis**

Summary characteristics were provided as frequencies (percentages) or means and standard deviations for admitted babies in each of the iNeo participating countries or regions. Discharge destinations were compared across the participating countries or networks as frequencies (percentages). The proportions of babies who had been discharged, died, or remained in neonatal care were plotted by post-menstrual age, stratified by gestational age at birth. LOS was compared by gestational age across all countries or regions, separated by survival or death before discharge. Medians and interquartile ranges (IQRs) were reported.

A multivariable linear regression model was applied to investigate the differences in LOS across countries or regions for babies who survived to discharge from neonatal care. The following baby characteristics known to be important for predicting LOS were included in the adjustment (7): gestational age, birthweight z-score (14), sex, and multiplicity. Coefficients and 95% confidence intervals (CI) were estimated.

Sensitivity analyses for babies discharged home from participating neonatal units were conducted. Discharge destination for each baby was obtained as last discharge from participating neonatal units.

All analyses were conducted using SAS 9.4 (SAS Institute Inc., Cary, NC) and a 2-sided significance level of 0.05.

**Research ethics approval**

All participating networks hold research ethics approval or the equivalent from their relevant local organizations to allow the transfer of their de-identified data to the iNeo Coordinating Centre at Mount Sinai Hospital in Toronto, Canada, where all analyses were undertaken. Approval specific for the purpose of this study was obtained from the iNeo Steering Committee and the Research Ethics Board at Mount Sinai Hospital.

**RESULTS**

**Study population**

Across the 11 participating countries, representing 10 networks, 31,989 babies were admitted to neonatal care at 24 to 28 weeks’ gestational age between 2014 and 2016. We excluded those discharged to non-neonatal facilities (n=573) or discharged before 34 weeks’ corrected age (n=2,356), those who stayed in neonatal care for longer than 6 months (n=769), and those with missing information about admission or discharge date (n=87). A total of 28,204 babies were included in our final analyses.

Summary statistics are provided for the 28,204 babies in **Table 1**. Approximately 28% of the babies included in our analyses were cared for in the UK (n=7961, **Table 1**). The percentage of babies delivered vaginally varied from 18.6% (Switzerland) to 48.2% (UK). Mean gestational age was similar across all countries, and mean birthweight ranged from 862 grams (standard deviation: 227 grams) in Japan to 967 grams (standard deviation: 256 grams) in Finland (**Table 1**).

In general, data were collected on most babies until they were discharged home from the neonatal unit (74.9% of babies overall, **Table 2**). However, the percentage of babies discharged home varied widely according to country and ranged from 49.1% (Canada) to 90.7% (Finland). The data collection system and discharge practices for each country are outlined in **Table 1**. The observed survival rate varied, with Israel having the highest mortality rate (23.4%, **Table 2**).

**Length of stay**

The observed median (inter quartile range) LOS is presented by country or network and week of gestational age at birth for babies who survived and those who died prior to discharge (**Table 3, online**). We noted wide variations between countries in observed LOS at all weeks of gestational age, with consistently higher LOS for Japan across all gestational ages. At 24 weeks’ gestational age, the median LOS of survivors ranged from 107 days (Israel) to 134 days (Japan); whereas, at 28 weeks’ gestational age, it ranged from 62 days (Finland) to 87 days (Japan). Across all gestational age groups, the median LOS for babies who survived ranged from 75 days (Finland) to 107 days (Japan), with an overall median LOS of 87 days (**Table 3, online**).

After adjusting for neonatal characteristics known to affect LOS, network differences still persisted among the babies who survived to discharge (**Table 4**). Sweden was selected as the reference network due to having the overall median LOS. The longest adjusted LOS was in Japan, at 20.7 days longer than the reference in Sweden. The shortest LOS was in Finland, at 4.8 days shorter than in Sweden. Gestational age at birth was an important demographic predictor of LOS, with mean LOS decreasing by 12.1 days for each week’s increase in gestational age. For each standard deviation increase in birthweight z-score, LOS decreased by 7.4 days. Multiplicity and male sex were associated with increases in mean LOS for survivors of 2.6 and 2.1 days, respectively.

As we noted differences between networks in the final discharge locations (**Table 2**), we repeated our adjusted analysis considering only the 21,132 babies within our data set who were discharged home from neonatal care (**Table 5, online**). Differences between the countries remained and were similar to those observed in the original adjusted analysis, with Japan having the longest adjusted LOS (23.3 days longer than the reference), and Finland having the shortest (4.1 days shorter than the reference). Gestational age also had a similar effect and was associated with a LOS reduction of 12.3 days per additional week of gestational age.

**Babies who died in neonatal care**

We noted less variation between networks in the observed median LOS among babies who died before discharge from neonatal care (**Table 3, online**). For babies born at 24 weeks’ gestational age, median LOS (survival time) ranged from 5 days (Finland) to 11 days (Sweden). For those born at 28 weeks’ gestational age, the range was from 4 days (Sweden) to 17 days (Italy). Across all gestational age groups, the median LOS for babies who died ranged from 3 days (Finland) to 12 days (Japan).

The proportions of babies who died, were discharged, or remained in neonatal care over time (by post-menstrual age) are presented by week of gestational age at birth in **Figure 1**.

**DISCUSSION**

In light of the increased survival of extremely preterm babies (2), attention has shifted to understanding variations in the length of neonatal stay. These stays can be especially long for babies born at earlier gestational ages. Prolonged time in neonatal care is known to increase exposure to adverse events, including infection, parental separation (6), and sensory stimuli potentially harmful for later development (15,16). Therefore, there is scientific rationale to minimize the amount of time spent in neonatal care. Parental involvement has been shown to reduce LOS (17); however, this desire to minimise LOS must be balanced with the need for specialist treatment and the importance of not discharging a baby before they are clinically ready to go home. Substantial differences in LOS have been observed in other multi-country studies, with one European study (9) reporting that average LOS varied by approximately 10 days from shortest to longest across all weeks of gestational age.

This large, international cohort includes data on nearly 30,000 extremely preterm babies and represents the first study to investigate LOS between high-income countries across the world. We provide more recent data than other international studies (8,9), and we carefully selected a population likely to be more homogeneous than other international studies by excluding births at the margins of viability, which during our study period for most countries was 24 weeks gestational age. In keeping with other studies (8), we identified differences that persisted even after adjusting for important neonatal characteristics known to affect LOS (7).

**Differences between countries**

In our study, Japan had the highest survival among babies born at 24 to 28 weeks’ gestation, the highest observed LOS for babies that died, and, the longest adjusted LOS. Higher survival has been previously reported for Japan at each individual gestational age, both from our data (18) and in other studies (19). We also speculate that, when survival increases, the rate of morbidities that lead to prolonged stays, such as bronchopulmonary dysplasia, also increases, potentially prolonging stays in neonatal units. Another explanation for the longer adjusted LOS, in addition to the higher survival rate, could be that babies in Japan are not transferred to step-down facilities during convalescence (as is the practice in many countries), and all care is instead delivered at tertiary care units until discharge home. These important differences in practice may explain the variations in LOS between different networks.

We found that Finland had the shortest observed LOS for babies who died and babies who were discharged home, and this finding persisted in the adjusted LOS for survivors. Finland represented one of the smallest cohorts in our study, and all babies in that network were either discharged home or died during their time in neonatal care. Previous research has demonstrated variability in LOS between units in Finland (20). Babies in Finland are also routinely discharged home while still receiving nasogastric feeds and supplementary oxygen, and these rates may be different to other countries, which potentially explains the slightly shortened LOS in this network.

**Differences in characteristics of the baby**

Beyond country differences, the most important predictor of LOS was gestational age at birth: each week’s increase in gestational age was associated with a reduction of approximately 12 days in LOS. This represents a change in LOS beyond that seen between most countries. This suggests that baby characteristics are as important, if not more important, than country differences in determining LOS. Other studies have suggested that characteristics of the baby are informative for predicting LOS (7); our work confirms that this effect persists internationally.

Birthweight z-score also had an important effect on LOS, with an increase of one standard deviation in birthweight z-score associated with a reduction in LOS of approximately 7 days. Another study (21) focusing on the LOS of babies with extremely low birthweight reported that the adjusted LOS for babies <500 grams was 118 days and decreased to 63 days for babies born at 900 grams to 999 grams. This Californian cohort (21) defined by birthweight may have included growth-restricted babies at a higher gestational age, and this was why we restricted our study to babies born at 24 to 28 weeks’ gestational age. This indicates the importance of appropriate intrauterine growth and monitoring in pregnancy, as the combination of low birthweight for gestational age and extreme gestational age is likely to have the strongest effect on neonatal LOS. Birthweight (22) and gestational age (23) are also key indicators of morbidity and mortality, which in turn influence LOS.

Male sex was associated with an increased average LOS of 2 days, in line with findings from a study in California (21) that reported a similar increased average adjusted LOS of 4 days for boys vs girls. While our study did not include data from the United States, this suggests sex may have similar effects on neonatal LOS in other countries. Similarly, multiplicity was associated with an increased LOS of approximately 3 days, comparable to that reported in a UK study where differences in LOS for multiples and singletons born at 24 to 28 weeks’ gestational age ranged from 1 to 3 days (24). The neonatal LOS of multiples is complex as it is likely to depend on the progress of their sibling(s) (24) if there are efforts to discharge siblings around the same time as one another. Regardless, in our study, sex and multiplicity appeared to have minimal effects on LOS.

**Strengths and limitations**

This study represents the first large, multi-country investigation of neonatal LOS for babies born extremely preterm outside of Europe. The sample size was large and protocols are applied to harmonize the data between countries. We also conducted a sensitivity analysis to investigate potential differences in data collection. However, we must acknowledge our limitations. First, the differences we observed could be have been due to variations in the countries’ neonatal systems (information about the different healthcare services can be found in: (13)); specifically, regarding their policies on providing convalescent care to preterm babies who survive and no longer require intensive care and monitoring but are not ready to go home. For example, in Japan, <10% of babies are retro-transferred to step-down units, while in Sweden, >75% are transferred (13). Similarly, other country-specific factors, such as whether care is delivered in step-down units or by community support teams (25), and the sizes and population densities within the countries, may explain some of the observed differences. These differences need to be explored in future research. Second, methods of data collection differ between countries. However, for those countries where data on the episode of neonatal care are collected for the entire stay and centralized, we were able to obtain information on LOS even when babies were transferred to other units. Third, our data did not allow us to investigate whether observed differences could be due to variations in the different countries’ management approaches for babies. We have reported variability in approaches to respiratory (26), cardiovascular (27), gastrointestinal (28), and end-of-life care (29) provision in these countries that may account for some of the differences we observed. We did not investigate care received while in the neonatal unit, including morbidities that can result in increased LOS, and future work should investigate this. Fourth, in some countries, the entire duration of a baby’s medical care was provided in the same neonatal unit, without need for transfer; whereas in other countries, patients were transferred for surgical or other specialist care. However, our interest was in the LOS within neonatal care services.

**CONCLUSIONS**

Our study identified differences of up to 3 weeks between networks in the adjusted neonatal LOS of babies born extremely preterm and admitted for neonatal care. Some of these relate to differences in survival, but key baby characteristics were also important predictors of LOS. Additionally, some of the unexplained variation between countries may relate to differences in clinical care practices, healthcare systems, and availability of community support. Variations in the countries’ data collection methods may also have affected our findings. These differences between countries require exploration in future studies which would contribute to understanding variation in healthcare resources and costs.

**Abbreviations**

EuroHOPE: European Health Care Outcomes, Performance and Efficiency

EPICE: Effective Perinatal Intensive Care In Europe study

iNeo: International Network for Evaluating Outcomes of Neonates

LOS: Length Of Stay

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**References**

(1) Lui K, Lee SK, Kusuda S, Adams M, Vento M, Reichman B, et al. Trends in Outcomes for Neonates Born Very Preterm and Very Low Birth Weight in 11 High-Income Countries. The Journal of Pediatrics 2019 Dec;215:32-40.e14.

(2) Santhakumaran S, Statnikov Y, Gray D, Battersby C, Ashby D, Modi N. Survival of very preterm infants admitted to neonatal care in England 2008–2014: time trends and regional variation. Archives of Disease in Childhood - Fetal and Neonatal Edition 2018 May;103:F208-F215.

(3) Glass H, Costarino A, Stayer S, Brett C, Cladis F, Davis P. Outcomes for Extremely Premature Infants. Anesthesia & Analgesia 2015 Jun;120:1337-1351.

(4) Lee HC, Bennett MV, Schulman J, Gould JB, Profit J. Estimating Length of Stay by Patient Type in the Neonatal Intensive Care Unit. American Journal of Perinatology 2016 Jul;33:751-757.

(5) Seaton SE, Barker L, Draper ES, Abrams KR, Modi N, Manktelow BN. Estimating neonatal length of stay for babies born very preterm. Archives of Disease in Childhood - Fetal and Neonatal Edition 2019 Mar;104:F182-F186.

(6) Flacking R, Lehtonen L, Thomson G, Axelin A, Ahlqvist S, Moran VH, et al. Closeness and separation in neonatal intensive care. Acta Paediatrica 2012 Oct;101:1032-1037.

(7) Seaton SE, Barker L, Jenkins D, Draper ES, Abrams KR, Manktelow BN. What factors predict length of stay in a neonatal unit: a systematic review. BMJ Open 2016 Oct;6:e010466.

(8) Maier RF, Blondel B, Piedvache A, Misselwitz B, Petrou S, Reempts P, et al. Duration and Time Trends in Hospital Stay for Very Preterm Infants Differ Across European Regions. Pediatric Critical Care Medicine 2018 Dec 1,;19:1153-1161.

(9) Numerato D, Fattore G, Tediosi F, Zanini R, Peltola M, Banks H, et al. Mortality and Length of Stay of Very Low Birth Weight and Very Preterm Infants: A EuroHOPE Study. PLoS ONE 2015;10:e0131685.

(10) Smith LK, Morisaki N, Morken N, Gissler M, Deb-Rinker P, Rouleau J, et al. An International Comparison of Death Classification at 22 to 25 Weeks’ Gestational Age. Pediatrics 2018 Jul;142:e20173324.

(11) Shah PS, Lui K, Sjörs G, Mirea L, Reichman B, Adams M, et al. Neonatal Outcomes of Very Low Birth Weight and Very Preterm Neonates: An International Comparison. The Journal of Pediatrics 2016;177:144-152.e6.

(12) Shah PS, Lui K, Reichman B, Norman M, Kusuda S, Lehtonen L, et al. The International Network for Evaluating Outcomes (iNeo) of neonates: evolution, progress and opportunities. Translational Pediatrics 2019;8:170-181.

(13) Kelly LE, Shah PS, Håkansson S, Kusuda S, Adams M, Lee SK, et al. Perinatal health services organization for preterm births: a multinational comparison. Journal of Perinatology 2017 Jul;37:762-768.

(14) Martin LJ, Sjörs G, Reichman B, Darlow BA, Morisaki N, Modi N, et al. Country‐Specific vs. Common Birthweight‐for‐Gestational Age References to Identify Small for Gestational Age Infants Born at 24–28 weeks: An International Study. Paediatric and perinatal epidemiology 2016 Sep;30:450-461.

(15) Santos J, Pearce SE, Stroustrup A. Impact of hospital-based environmental exposures on neurodevelopmental outcomes of preterm infants. Current opinion in pediatrics 2015 Apr;27:254-260.

(16) Vohr B, McGowan E, McKinley L, Tucker R, Keszler L, Alksninis B. Differential Effects of the Single-Family Room Neonatal Intensive Care Unit on 18- to 24-Month Bayley Scores of Preterm Infants. The Journal of pediatrics 2017;185:42-48.e1.

(17) Lehtonen L, Lee SK, Kusuda S, Lui K, Norman M, Bassler D, et al. Family Rooms in NICUs and Neonatal Outcomes: An International Survey and Linked Cohort Study. 2020 Jun 1.

(18) Helenius K, Sjörs G, Shah PS, Modi N, Reichman B, Morisaki N, et al. Survival in Very Preterm Infants: An International Comparison of 10 National Neonatal Networks. Pediatrics 2017 Dec;140:e20171264.

(19) Isayama T. The clinical management and outcomes of extremely preterm infants in Japan: past, present, and future. Translational pediatrics 2019 Jul;8:199-211.

(20) Korvenranta E, Linna M, Häkkinen U, Peltola M, Andersson S, Gissler M, et al. Differences in the length of initial hospital stay in very preterm infants. Acta Pædiatrica 2007 Oct;96:1416-1420.

(21) Lee HC, Bennett MV, Schulman J, Gould JB. Accounting for variation in length of NICU stay for extremely low birth weight infants. Journal of Perinatology 2013 Nov;33:872-876.

(22) McIntire DD, Bloom SL, Casey BM, Leveno KJ. Birth Weight in Relation to Morbidity and Mortality among Newborn Infants. The New England Journal of Medicine 1999 Apr 22,;340:1234-1238.

(23) Manuck TA, Rice MM, Bailit JL, Grobman WA, Reddy UM, Wapner RJ, et al. Preterm neonatal morbidity and mortality by gestational age: a contemporary cohort. American Journal of Obstetrics and Gynecology 2016;215:103.e1-103.e14.

(24) Seaton SE, Draper ES, Abrams KR, Modi N, Manktelow BN. Can we estimate the length of stay of very preterm multiples? Archives of Disease in Childhood - Fetal and Neonatal Edition 2019 Sep;104:F568-F570.

(25) Langley D, Hollis S, Friede T, MacGregor D, Gatrell A. Impact of community neonatal services: a multicentre survey. Archives of Disease in Childhood: Fetal and Neonatal Edition 2002;87:F204.

(26) Beltempo M, Isayama T, Vento M, Lui K, Kusuda S, Lehtonen L, et al. Respiratory Management of Extremely Preterm Infants: An International Survey. Neonatology 2018;114:28-36.

(27) Isayama T, Kusuda S, Reichman B, Lee SK, Lehtonen L, Norman M, et al. Neonatal Intensive Care Unit-Level Patent Ductus Arteriosus Treatment Rates and Outcomes in Infants Born Extremely Preterm. The Journal of Pediatrics 2020 May;220:34-39.e5.

(28) Adams M, Bassler D, Darlow BA, Lui K, Reichman B, Hakansson S, et al. Preventive strategies and factors associated with surgically treated necrotising enterocolitis in extremely preterm infants: an international unit survey linked with retrospective cohort data analysis. BMJ Open 2019 Oct;9:e031086.

(29) Helenius K, Morisaki N, Kusuda S, Shah PS, Norman M, Lehtonen L, et al. Survey shows marked variations in approaches to redirection of care for critically ill very preterm infants in 11 countries. Acta Paediatrica 2019;109:1338-1345.

**Figure 1**: Deaths, Discharges From Neonatal Care, and Babies Remaining in Neonatal Care: Observed Percentages Over Time by Gestational Age

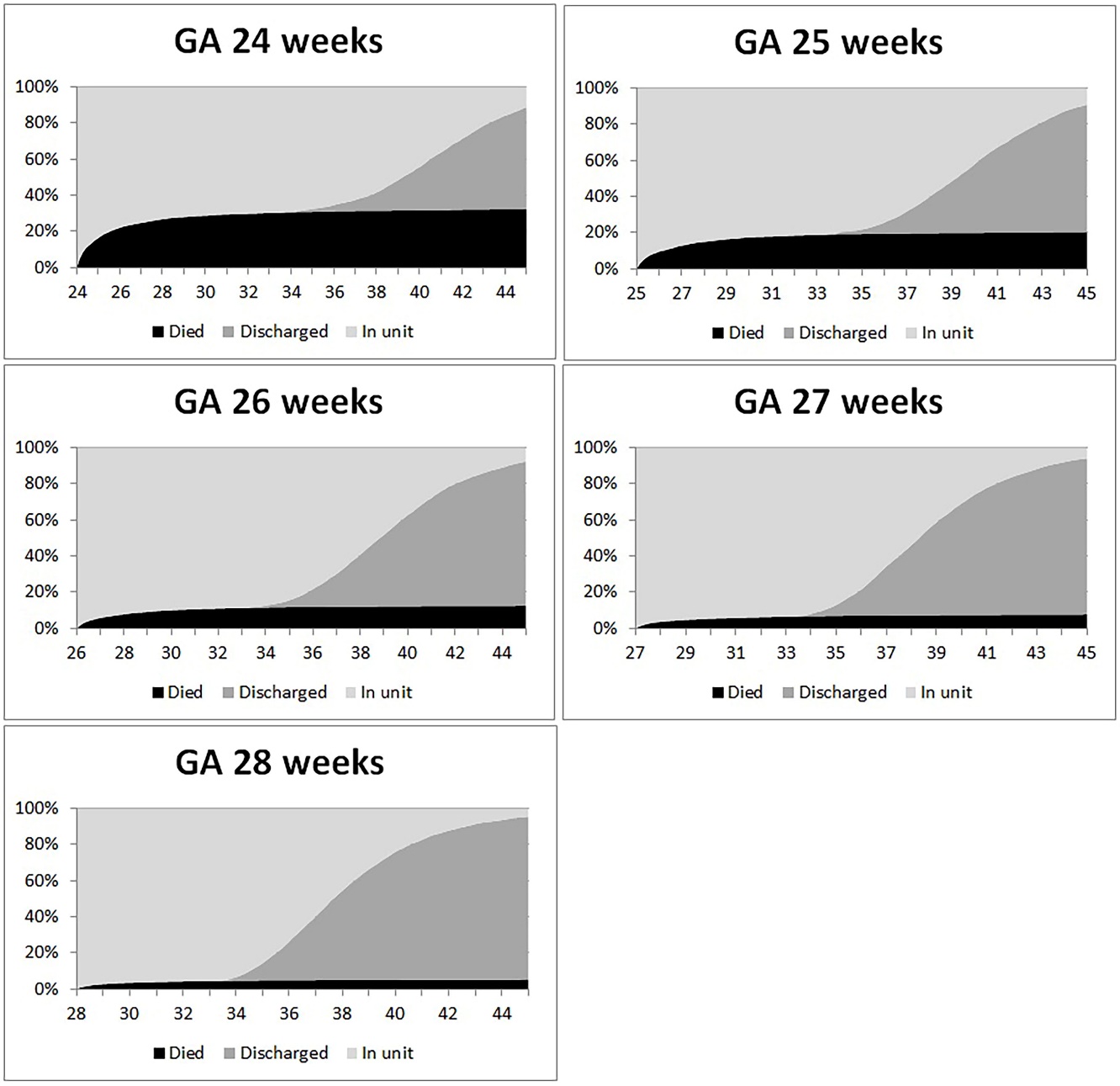


Figure 1 footnote: Abbreviation: GA, gestational age at birth.

Y-axis: Percentage of babies remaining in unit or who were discharged or died. X-axis: Post-menstrual age in weeks. Note that some babies remained in the neonatal unit at the post-menstrual age when the graphs were truncated.

**Table 1. Baseline Characteristics of the Included Population**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Country/**  **Network** | **Total,**  **No.** | **Data Collection** | **Gestational Age (weeks), Mean (SD)** | **Birthweight (g), Mean (SD)** | **Birthweight Z-score, Mean (SD)** | **Vaginal Delivery, No. (%)** | **Male, No. (%)** | **Multiple births, N (%)** |
| Australia & New Zealand | 4,337 | Captured entire neonatal stay prior to discharge home or death | 26.4 (1.4) | 946 (237) | 0.14 (0.99) | 1,754 (40.6) | 2,382 (54.9) | 1,130 (26.0) |
| Canada | 3,624 | Captured neonatal stay in level 3 NICUs and not for stay in level 2 neonatal units or other medical services | 26.2 (1.4) | 910 (239) | -0.03 (0.93) | 1,427 (39.5) | 1,927 (53.3) | 883 (24.4) |
| Finland | 398 | Captured entire neonatal stay prior to discharge home or death | 26.5 (1.3) | 967 (256) | 0.05 (0.93) | 99 (34.3) | 207 (52.0) | 96 (24.1) |
| Israel | 1,767 | Captured entire neonatal stay prior to discharge home or death | 26.4 (1.4) | 908 (224) | -0.04 (0.93) | 504 (28.5) | 975 (55.2) | 656 (37.1) |
| Japan | 4,936 | Captured entire neonatal stay prior to discharge home or death or transfer to other medical services | 26.3 (1.4) | 862 (227) | -0.19 (1.01) | 917 (19.0) | 2,647 (53.6) | 948 (19.2) |
| Spain | 2,798 | Captured entire neonatal stay prior to discharge home or death or transfer to other medical services | 26.5 (1.3) | 908 (222) | -0.08 (0.97) | 961 (34.4) | 1,488 (53.2) | 850 (30.4) |
| Sweden | 1,226 | Captured entire neonatal stay prior to discharge home or death or transfer to other medical services | 26.4 (1.4) | 928 (245) | -0.06 (0.91) | 354 (29.3) | 693 (56.5) | 311 (25.4) |
| Switzerland | 902 | Captured entire neonatal stay prior to discharge home or death or transfer to other medical services | 26.4 (1.4) | 888 (231) | -0.17 (0.87) | 168 (18.6) | 504 (55.9) | 281 (31.1) |
| Italy (Tuscany) | 255 | Captured entire neonatal stay prior to discharge home or death or transfer to other medical services | 26.4 (1.4) | 882 (248) | 0.16 (1.01) | 75 (29.4) | 131 (51.4) | 85 (33.3) |
| UK (England) | 7,961 | Captured entire neonatal stay prior to discharge home or death or transfer to other medical services | 26.4 (1.4) | 916 (227) | -0.16 (0.97) | 3,652 (48.2) | 4,235 (53.3) | 2,032 (25.6) |

**Table 2. Discharge Destination for Included Babies by Country/Network**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Country/Network** | **Total, No.** | **Discharged Home, No. (%)** | **Discharged to Other Institute, No. (%)** | **Died in Neonatal Care, No. (%)** | **Missing Data, No. (%)** |
| Australia & New Zealand | 4,337 | 3,794 (87.5) | 60 (1.4) | 483 (11.1) | 0 (0) |
| Canada | 3,624 | 1,778 (49.1) | 1,328 (36.6) | 503 (13.9) | 15 (0.4) |
| Finland | 398 | 361 (90.7) | 0 (0) | 37 (9.3) | 0 (0) |
| Israel | 1,767 | 1,353 (76.6) | 0 (0) | 414 (23.4) | 0 (0) |
| Japan | 4,936 | 3,976 (80.6) | 476 (9.6) | 310 (6.3) | 174 (3.5) |
| Spain | 2,798 | 2,143 (76.6) | 65 (2.3) | 566 (20.2) | 24 (0.9) |
| Sweden | 1,226 | 984 (80.3) | 104 (8.5) | 138 (11.3) | 0 (0) |
| Switzerland | 902 | 584 (64.8) | 146 (16.2) | 139 (15.4) | 33 (3.7) |
| Italy (Tuscany) | 255 | 197 (77.3) | 8 (3.1) | 47 (18.4) | 3 (1.2) |
| UK (England) | 7,961 | 5,962 (74.9) | 801 (10.1) | 1,166 (14.7) | 32 (0.4) |
| **All networks** | **28,204** | **21,132 (74.9)** | **2,988 (10.6)** | **3,803 (13.5)** | **281 (1.0)** |

**Table 3 (online). Median (IQR) Length of Stay by Country/Network and Gestational Age**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **Gestational age at birth** | | | | |  |
| **Country/ Network** | **24 Weeks** | **25 Weeks** | **26 Weeks** | **27 Weeks** | **28 Weeks** | **Total** |
| **Babies Who Survived to Discharge** | | | | | | |
| Australia & New Zealand | 118  (108, 136) | 107  (94, 125) | 94  (83, 108) | 82  (72, 95) | 69  (60, 80) | 87  (71, 106) |
| Canada | 119  (102, 134) | 107  (88, 123) | 91  (75, 105) | 78  (65, 95) | 67  (52, 83) | 87  (68, 110) |
| Finland | 117  (101, 131) | 95  (87, 105) | 81  (73, 89) | 70  (62, 83) | 62  (55, 72) | 75  (63, 91) |
| Israel | 107  (98, 128) | 98  (87, 114) | 86  (74, 102) | 73  (65, 88) | 63  (55, 76) | 77  (63, 96) |
| Japan | 134  (121, 152) | 122  (109, 138) | 110  (98, 128) | 99  (86, 114) | 87  (76, 103) | 107  (89, 128) |
| Spain | 109  (96, 128) | 96  (84, 114) | 85  (74, 98) | 74  (64, 89) | 63  (53, 76) | 77  (63, 94) |
| Sweden | 114  (98, 130) | 96  (84, 112) | 89  (75, 106) | 80  (66, 91) | 66  (54, 79) | 83  (67, 102) |
| Switzerland | 117  (101, 130) | 101  (87, 120) | 89  (77, 103) | 79  (69, 97) | 70  (58, 83) | 84  (69, 103) |
| Italy (Tuscany) | 129  (116, 145) | 107  (95, 118) | 98  (84, 108) | 74  (62, 91) | 66  (59, 83) | 86  (66, 107) |
| UK (England) | 115  (102, 132) | 101  (88, 117) | 89  (77, 105) | 77  (65, 91) | 64  (54, 78) | 82  (66, 103) |
| **All networks** | **121**  **(105, 138)** | **106**  **(91, 125)** | **94**  **(80, 110)** | **81**  **(68, 97)** | **69**  **(57, 84)** | **87**  **(69, 109)** |
| **Babies Who Died** | | | | | |  |
| Australia & New Zealand | 7  (2, 21) | 11  (4, 31) | 7  (1, 28) | 18  (5, 51) | 9  (2, 29) | 9  (2, 29) |
| Canada | 8  (4, 19) | 13  (4, 26) | 13  (5, 27) | 6  (2, 21) | 5  (2, 44) | 10  (4,24) |
| Finland | 5  (0, 28) | 2  (1, 15) | 8  (2, 15) | 3  (2, 5) | 9  (3, 15.5) | 3  (2, 15) |
| Israel | 6  (3, 13) | 8  (3, 17) | 8  (3, 16) | 9  (3, 28) | 8  (3, 35) | 8  (3, 17) |
| Japan | 10  (3, 29) | 13  (2, 34) | 19  (3, 46) | 16  (3, 70) | 5  (2, 29) | 12  (2, 36) |
| Spain | 8  (2, 18) | 8  (3, 18) | 7  (3, 17) | 7  (3, 22) | 9  (4, 18) | 8  (3, 18) |
| Sweden | 11  (3, 37) | 8  (2, 26) | 6  (3, 14) | 5  (3, 19) | 4  (2, 13) | 6  (3, 26) |
| Switzerland | 6  (4, 11) | 4  (2, 10) | 12  (3, 22) | 9  (3, 28) | 15  (2, 38) | 6  (3, 14) |
| Italy (Tuscany) | 10  (2, 25) | 3  (3, 13) | 2  (1, 4) | 13  (6, 22) | 17  (16, 21) | 8  (2, 21) |
| UK (England) | 8  (1, 27) | 11  (2, 29) | 8  (2, 27) | 8  (2, 32) | 5  (1, 25.5) | 8  (2, 28) |
| **All networks** | **7**  **(2, 21)** | **9**  **(3, 24)** | **9**  **(3, 24)** | **9**  **(3, 31)** | **7**  **(2, 25)** | **8**  **(2, 24)** |

**Table 4. Multivariable Analysis: Length of Stay for Babies who Survived to Discharge**

|  |  |
| --- | --- |
| **Variable** | **Coefficient (95% CI), days** |
| Country/Network  Australia & New Zealand  Canada  Finland  Israel  Japan  Spain  **Sweden**  Switzerland  Italy (Tuscany)  UK (England) | 6.87 (5.45, 8.30)  2.37 (0.92, 3.83)  -4.77 (-7.28, -2.27)  -0.48 (-2.17, 1.20)  20.7 (19.3, 22.1)  -2.05 (-3.58, -0.52)  **Reference**  1.97 (0.02, 3.92)  8.10 (4.98, 11.2)  -0.02 (-1.37, 1.33) |
| Gestational age (each week’s increase) | -12.1 (-12.3, -11.9) |
| Birthweight z-score | -7.43 (-7.73, -7.15) |
| Male sex | 2.09 (1.56, 2.62) |
| Multiplicity | 2.55 (1.95, 3.16) |

*P* < .01 for all variables.

**Table 5 (online). Sensitivity Analysis: Length of Stay Restricted to Babies Discharged Home**

|  |  |
| --- | --- |
| **Variable** | **Coefficient (95% CI), days** |
| Country/Network  Australia & New Zealand  Canada  Finland  Israel  Japan  Spain  **Sweden**  Switzerland  Italy (Tuscany)  UK (England) | 7.81 (6.43, 9.18)  9.24 (7.71, 10.8)  -4.05 (-6.41, -1.70)  0.20 (-1.41, 1.81)  23.3 (22.0, 24.7)  -1.33 (-2.81, 0.15)  **Reference**  4.26 (2.26, 6.26)  9.08 (6.09, 12.1)  0.56 (-0.76, 1.88) |
| Gestational age (each week’s increase) | -12.3 (-12.5, -12.1) |
| Birthweight z-score | -7.79 (-8.07, -7.50) |
| Male sex | 1.86 (1.34, 2.39) |
| Multiplicity | 3.03 (2.42, 3.63) |

*P* < .01 for all variables.